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# **Relative Value Trading Strategies**



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# **Relative Value Trading Strategies**

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# **Relative Value Trading Strategies**

## **Arbitrage Strategies**

### **Rich/Cheap Analysis**

Rich cheap analysis is looking for under-valued and over-valued assets. The idea is to sell the over-valued assets and buy the undervalued assets.

Rich / Cheap analysis is sometimes referred to as spread analysis. A recent classic case of rich/cheap portfolio management is Long Term Capital Markets-LTCM (hedge fund in US).

LTCM took long positions in non-government debt and short positions in government debt. The assumption was that the credit spread was too wide. As credit spreads widened LTCM experienced large losses.

### **US Government Bond Example**

Bonds with greater duration have greater price risk. The yield curve compares yields on bonds with different maturities in order to obtain information about yield and maturity.

It is therefore reasonable to ask if there is a relationship between yield and price risk, or, more specifically, duration. The table below compares maturities and YTM for U.S.

Treasuries having approximately 20 years remaining maturity in early June 1998.

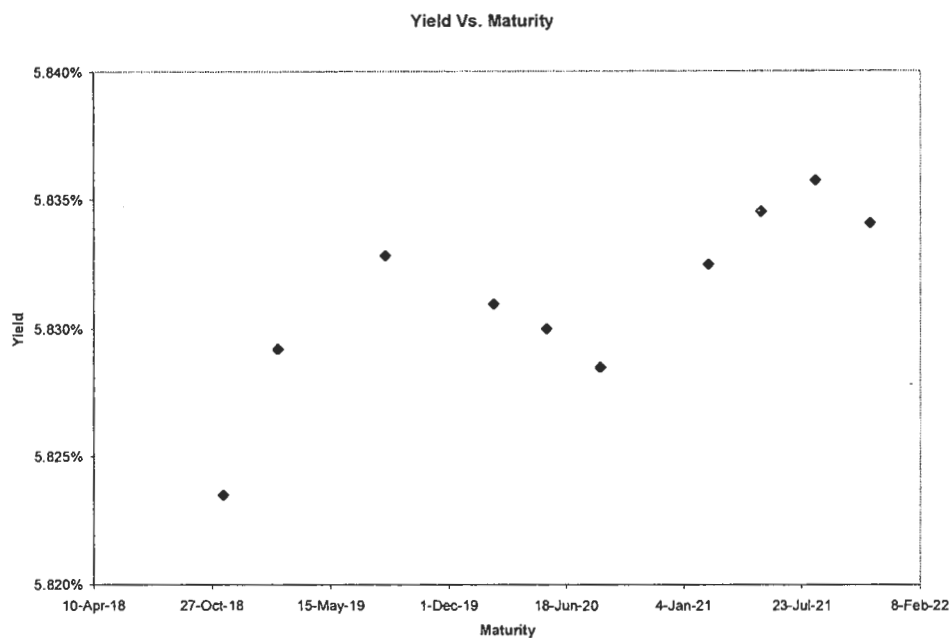
<u>Maturity</u>	<u>Yield</u>	<u>Coupon</u>	<u>Price</u>	<u>Duration</u>
15-Nov-18	5.823%	9.000%	137 21/32	11.1442
15-Feb-19	5.829%	8.875%	136 10/32	11.0659
15-Aug-19	5.833%	8.125%	127 21/32	11.3972
15-Feb-20	5.831%	8.500%	132 19/32	11.4380
15-May-20	5.830%	8.750%	135 28/32	11.6260
15-Aug-20	5.829%	8.750%	136 3/32	11.5122
15-Feb-21	5.832%	7.875%	125 16/32	11.8761
15-May-21	5.835%	8.125%	128 24/32	12.0539
15-Aug-21	5.836%	8.125%	128 28/32	11.9324
15-Nov-21	5.834%	8.000%	127 15/32	12.2186

We can look at this particular portion of the yield curve graphically in the usual way:



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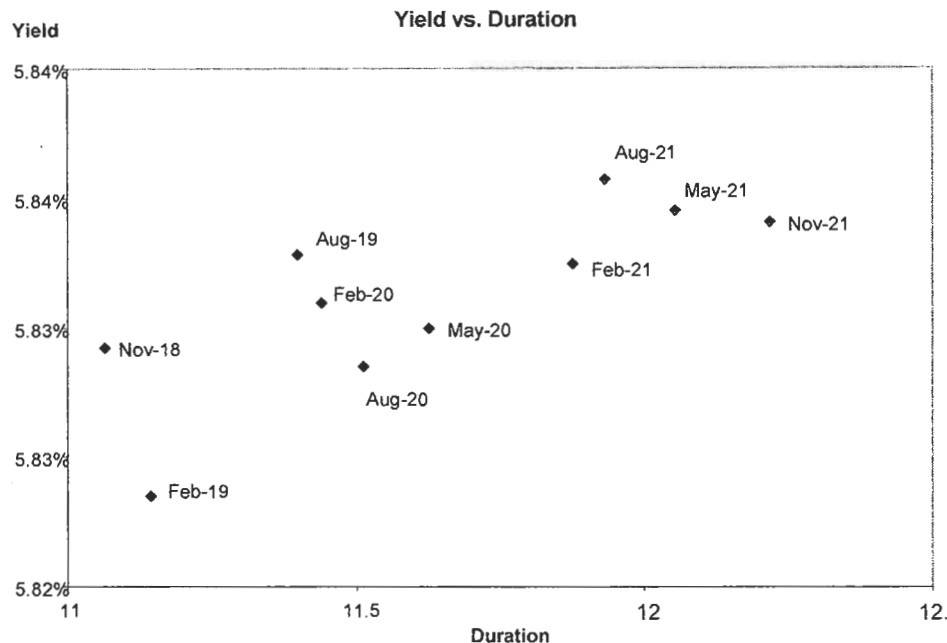
The yield on the bond maturing 15 August 2019 looks about a basis point too high, but otherwise the curve is fairly ordinary looking.



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We can also compare yield with duration:



The Aug-19 bond trades at a slightly lower duration but higher yield than the Feb-20 and Aug-20 bonds. This means that the Aug-19 may be trading cheap relative to the other two bonds.

One strategy would be to buy the Aug-19 and sell the Feb-20 or Aug-20 bond.

### Barbell/ Bullet analysis

A trading strategy employing views on the shape of the yield curve might be to trade two bonds — one short in maturity and the other long — against a third bond of medium maturity.

The combination of the two bonds is called a **barbell** (the name for a piece of weightlifting equipment consisting of a hand-held weight with a disk-shaped weight on each end).

The single bond is called a **bullet**.

The goal of this trade is to create arbitrage profits without taking any risk. We are thus looking to take a long position in one and a short position in the other such that the two positions have equal duration risk and market values.



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To illustrate this trading strategy, let us use the following three bonds (value date is 10 June-1998):

<u>Bond</u>	<u>Maturity</u>	<u>Coupon</u>	<u>Price</u>	<u>Accrued</u>	<u>Dirty Price</u>	<u>YTM</u>	<u>DEM Duration</u>
A	20-Apr-00	3.500%	98.766	0.486	99.252	4.198%	1.740
B	04-Jul-07	7.000%	113.866	6.533	120.399	5.054%	7.755
C	20-Jul-03	4.500%	98.958	4.000	102.958	4.732%	4.421

The yield curve in DEM is shown below.

Currency	DEM
LIBOR	Rate
O/N	3.55%
1M LIBOR	3.55%
3M LIBOR	3.59%
6M LIBOR	3.69%
12M LIBOR	3.95%
LIBOR Quote Convention	Act/360
Swap Rate	Rate
2 Yr	4.24%
3 Yr	4.45%
4 Yr	4.59%
5 Yr	4.72%
6 Yr	4.83%
7 Yr	4.93%
8 Yr	5.01%
9 Yr	5.05%
10 Yr	5.12%
Swap Quote Convention	30/360, A

The barbell will consist of a position in bonds A and B. The bullet will be a position in C.

DEM duration is calculated by multiplying the modified duration times the bond's dirty price. It represents the amount of absolute price change the bond will have for a 1% change in interest rates.

Using Bond A can show this.

Duration for bond is calculated as 1.827.

Modified duration is duration divided by 1 plus YTM:

$$\text{ModifiedDuration} = \frac{1.827}{(1 + 4.198\%)} = 1.753$$



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Modified duration times the bond's dirty price gives us the DEM duration:

$$\text{DEMDuration} = 1.753 \times 99.252\% = 1.740$$

DEM duration can be interpreted as the absolute amount of price change resulting from a 1% change in the bond's YTM.

### Calculating Barbell and Bullet Positions

We need to take a position in Bonds A and B that has the same market value as Bond C. That way, we can finance the trade.

At the same time we want the dollar duration of both positions to be the same. For small movements in interest rates, our two positions will have the same risk.

The first condition might be described as follows:

$$Z \times [X \times MV_A + (1 - X) \times MV_B] = MV_C$$

where:

- Z = The percent of face value of A and B needed to equal C
- X = The percent of A needed
- 1 - X = The percent of B needed
- MV = The market value of each asset

The second condition can be described similarly as follows:

$$Z \times [X \times DD_A + (1 - X) \times DD_B] = DD_C$$

where:

- Z = The percent of face value of A and B needed to equal C
- X = The percent of A needed
- 1 - X = The percent of B needed
- DD = The dollar duration of each asset

Using algebra, we can "solve" these two equations simultaneously to determine the exact amounts of A and B needed to exactly offset both the market value and dollar duration of C. Doing so we obtain the following equation for Z:

$$Z = \frac{DD_C - MV_C \times R}{DD_B - MV_B \times R}$$

$$\text{where: } R = \frac{DD_A - DD_B}{MV_A - MV_B}$$

The percent of Bond A is calculated as follows:

$$X = \frac{DD_B \times Z - DD_C}{DD_B \times Z - DD_A \times Z}$$



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Using the above equations we can solve for the following amounts of A and B:

$$\begin{aligned} X &= 50.6321\% \\ 1 X &= 49.3679\% \\ Z &= 93.8608\% \end{aligned}$$

The market value of the barbell is equal to the market value of Bond C:

$$93.8608\% \times [50.6321\% \times 99.252\% + 49.3679\% \times 120.399\%] = 102.958\% = MV_C$$

The DEM duration of the barbell is also equal to that of Bond C:

$$93.8608\% \times [50.6321\% \times 1.740 + 49.3679\% \times 7.755] = 4.421 = DD_C$$

The yield of the barbell can be calculated several different ways: weighted average yield, cash flow yield or horizon yield. For now we use the simple weighted average yield.

This is calculated using the respective market value percentages as weights:

$$45.8132\% \times 4.198\% + 54.1867\% \times 5.054\% = 4.662\%$$

We can now describe our two possible positions more completely:

<u>Bond</u>	<u>Maturity</u>	<u>Coupon</u>	<u>Price</u>	<u>Accrued</u>	<u>Dirty Price</u>	<u>YTM</u>	<u>DEM Duration</u>
C	20-Jul-03	4.500%	98.958	4.000	102.958	4.732%	4.421
<u>Barbell</u>							
A	20-Apr-00	3.500%	98.766	0.486	99.252	4.198%	0.827
B	04-Jul-07	7.000%	113.866	6.533	<u>120.399</u>	<u>5.054%</u>	<u>3.394</u>
Total					102.958	4.662%	4.421



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Assuming a principal of DEM 10 mio full details are below:

	<u>Bullet</u>	<u>Barbell</u>		<u>Barbell</u>		
Issue	<u>C</u>	<u>A</u>	<u>B</u>	<u>A</u>	<u>B</u>	<u>Net</u>
Coupon	4.500%	3.500%	7.000%	3.500%	7.000%	
Maturity	20-Jul-03	20-Apr-00	04-Jul-07	20-Apr-00	04-Jul-07	
Clean Pr.	98.96	98.77	113.87	46.937	52.762	
Accrued	4.000	0.486	6.533	0.231	3.027	
Dirty Pr.	102.958	99.252	120.399	47.168	55.789	102.958
Yield	4.732%	4.198%	5.054%	1.92%	2.74%	4.662%
Dur.	4.497	1.827	6.767	0.868	3.136	
Mod. Dur.	4.294	1.753	6.441	0.833	2.985	
Dm Dur.	4.421	1.740	7.755	0.827	3.594	4.421
Par	DM 9,712,726	DM 4,615,850	DM 4,500,595			DM 9,116,445
Market	DM 10,000,000	DM 4,581,328	DM 5,418,672			DM 10,000,000

### Simple Yield Comparison

This yields a not-very-interesting result: It appears that we can grab a yield gain of only 0.06% by buying Bond C and selling the Barbell. The transaction is self-financing and of identical dollar duration. Intuitively, it seems reasonable that the yields should be about the same.

But is the yield difference calculated correctly?

### Relative Value

In addition to weighted average yield, we can also compare the yields on the barbell and the bullet two other ways: cash flow yield and horizon yield.

Both of these are "better" ways of looking at the relative value of each strategy.

### Cash Flow/Duration Weighted Yield

Calculating the simple average of the yields to maturity of the constituent bonds is a very rough approximation of the barbell's actual YTM.

This is because the two bonds have very different maturities.

YTM should be understood to be the single cash flow discounting rate which, when used to price each of the cash flows in the barbell, returns their aggregate market value.

There is no easy way to solve for this YTM. The easiest approach is to set it up on a spreadsheet and find the yield value through a solver function.

### Approximate Cash Flow YTM

It is possible to closely approximate the cash flow yield in a portfolio by using the **DEM-duration-weighted average yield** instead of the simple weighted average yield.



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$$\frac{4.198\% \times 0.827 + 5.054\% \times 3.594}{0.827 + 3.594} = 4.894\%$$

We can now describe our two possible positions more accurately:

<u>Bond</u>	<u>Maturity</u>	<u>Coupon</u>	<u>Price</u>	<u>Accrued</u>	<u>Dirty Price</u>	<u>YTM</u>	<u>DEM</u> <u>Duration</u>
C	20-Jul-03	4.500%	98.958	4.000	102.958	4.732%	4.421
<u>Barbell</u>							
A	20-Apr-00	3.500%	98.766	0.486	99.252	4.198%	0.827
B	04-Jul-07	7.000%	113.866	6.533	120.399	5.054%	3.394
Total					102.958	4.894%	4.421

This result is far more interesting: It appears that we can grab a yield gain of 0.16% by buying the Barbell and selling Bond C.

Is there any explanation for this? Does the relative riskiness of the barbell versus the bullet give us an explanation?

### Relative Riskiness

To measure the relative riskiness of the barbell versus the bullet, we need to compute the **convexity** of both.

Convexity is calculated as follows:

The formula asks that we sum all of the products of  $PV \times \text{Time}$  plus  $PV \times \text{Time}^2$ , and then divide by  $(1+YTM/2)^2$ :

$$\text{Convexity} = \frac{\sum_{t=1}^n (t^2 \times PVCF_t + t \times PVCF_t)}{\text{Dirty Price} \left(1 + \frac{YTM}{2}\right)^2}$$

DEM convexity is calculated by multiplying the convexity by the market value of the bond(s).

Convexity can be understood to mean the pricing error resulting from using modified duration to predict the new price of the bullet. It is best to think of it as a relative term – relative to the level of yields and duration.

### Bullet Convexity

For the bullet convexity is calculated as 24.284.

The DEM convexity for the bullet:

$$\text{DEM Convexity} = 24.2894 \times 102.958\% = 25.002$$



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### Barbell Convexity

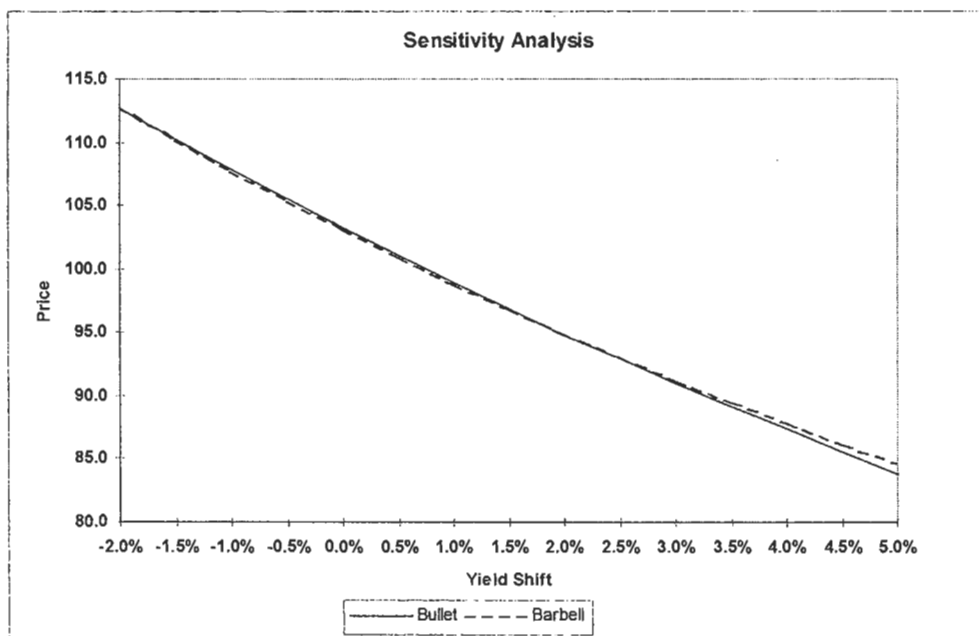
For the barbell convexity is calculated below:

<u>Bond</u>	<u>Maturity</u>	<u>Coupon</u>	<u>Dirty Price</u>	<u>Convexity</u>	<u>DEM Convexity</u>
A	20-Apr-00	3.500%	47.168	4.788	2.258
B	04-Jul-07	7.000%	55.789	56.514	31.649
Total			102.958		33.787

We can now describe our two possible positions more accurately:

<u>Bond</u>	<u>Maturity</u>	<u>Coupon</u>	<u>Dirty Price</u>	<u>YTM</u>	<u>DEM Duration</u>	<u>Dem Convexity</u>
C	20-Jul-03	4.500%	102.958	4.732%	4.421	25.002
<u>Barbell</u>						
A	20-Apr-00	3.500%	99.252	4.198%	0.827	
B	04-Jul-07	7.000%	120.399	5.054%	3.394	
Total			102.958	4.894%	4.421	33.787

A graph of the price performance of the two strategies for yield curve shift is shown. For large shift in rates the barbell strategy will outperform the bullet strategy due to larger convexity.



We cannot only take a yield gain of 0.18% by buying the Barbell and selling Bond C, but we get a position with far greater convexity, which, as we have seen, is a desirable property.



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Buying the barbell and selling the bullet gives a position of being long convexity. If rates move the owner of convexity will benefit. However, there should always be an initial cost to buying convexity. If convexity was free, risk-free profits could always be generated. It does not look like we have paid for convexity.

Something doesn't add up here!

### Horizon Yield

Our analysis so far has paid no attention to the "expected developments" of yields over time. Specifically, we are treating each cash flow as if it can be reinvested at the various IRRs we are using.

Horizon yield is similar to realized compound yield in that it wants to treat the reinvestment of each cash flow at a market rate.

The simplest case we will use is to assume yields do not change after six months.

The pricing for the strategies follows:

<u>Strategy</u>	<u>Bullet</u>	<u>Barbell Bonds</u>		<u>Net</u>
	<u>C</u>	<u>A</u>	<u>B</u>	
Coupon	4.500%	3.500%	7.000%	
Issue date	20-Jul-98	20-Apr-98	04-Jul-98	
Coupon Date	20-Jul-99	20-Apr-99	04-Jul-99	
Maturity	20-Jul-03	20-Apr-00	04-Jul-07	
Clean Price	99.289	99.264	113.382	
Accrued	1.750	2.236	3.033	
Dirty Price	101.039	101.500	116.415	
Yield	4.67%	4.05%	5.03%	
Duration	4.20	1.33	6.68	
Modified Duration	4.010	1.275	6.361	
DEM Duration	4.051	1.295	7.405	
Par Value	9,712,726	4,615,850	4,500,595	9,116,445
Market Value	9,813,595	4,685,093	5,239,366	9,924,459
Coupon	437,073		315,042	315,042
Interest On Coupon	6,858		5,496	5,496
Position	10,257,526	4,685,093	5,559,903	10,244,996
6-Month Return	5.15%	4.53%	5.21%	4.90%

The six months returns are calculated assuming an original principal value of DEM 10 mio.

Now the bullet strategy proves to be the better strategy. If rates are stable buying the barbell and selling the bullet ends up costing money. This is one way to look at the implied cost of buying convexity.

The bullet yields 5.15% and the barbell yields 4.90%. Buying the barbell and selling the bullet would produce a 6-month loss of 12,529.



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### *Horizon Value and Volatility*

The resolution of this arbitrage lies in modeling future developments in the yield curve to incorporate interest rate volatility.

### Parallel Yield Curve Shifts

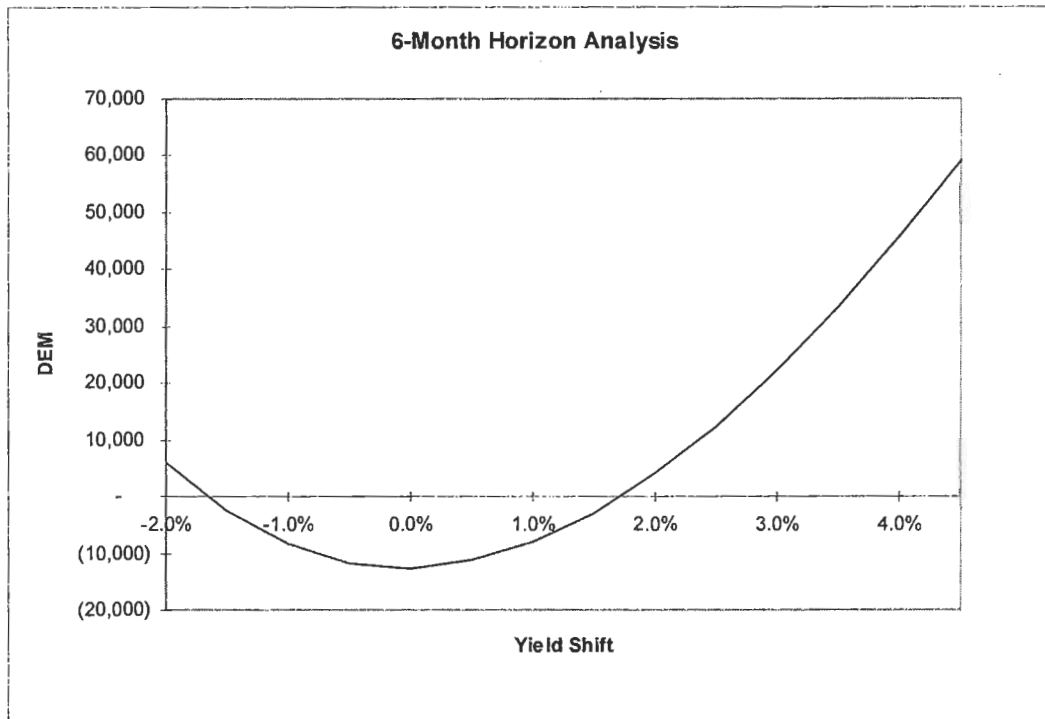
For parallel yield curve shifts the results of the barbell vs. bullet strategy are shown below:

Curve $\Delta$	Annualized Return			DEM
	Bullet	Barbell	Difference	
-2.00%	21.75%	21.87%	0.12%	6,100
-1.50%	17.43%	17.38%	-0.05%	(2,541)
-1.00%	13.23%	13.06%	-0.17%	(8,384)
-0.50%	9.14%	8.90%	-0.23%	(11,647)
0.00%	5.15%	4.90%	-0.25%	(12,529)
0.50%	1.27%	1.04%	-0.22%	(11,221)
1.00%	-2.52%	-2.68%	-0.16%	(7,898)
1.50%	-6.21%	-6.26%	-0.05%	(2,725)
2.00%	-9.80%	-9.72%	0.08%	4,145
2.50%	-13.31%	-13.05%	0.25%	12,567
3.00%	-16.72%	-16.27%	0.45%	22,408
3.50%	-20.05%	-19.38%	0.67%	33,543
4.00%	-23.30%	-22.38%	0.92%	45,856
4.50%	-26.47%	-25.28%	1.18%	59,236
5.00%	-29.56%	-28.09%	1.47%	73,582



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The barbell strategy will outperform the bullet strategy for large parallel yield curve shifts. This is because the barbell position has greater convexity than the bullet position.

### Non-Parallel Yield Curve Shifts

While the results for parallel yield shifts are interesting, the market rarely moves in a parallel fashion. The analysis in this section changes the shape of the yield curve and examines the performance of the positions.

For non-parallel yield curve shift the results of the barbell vs. bullet strategy are shown below

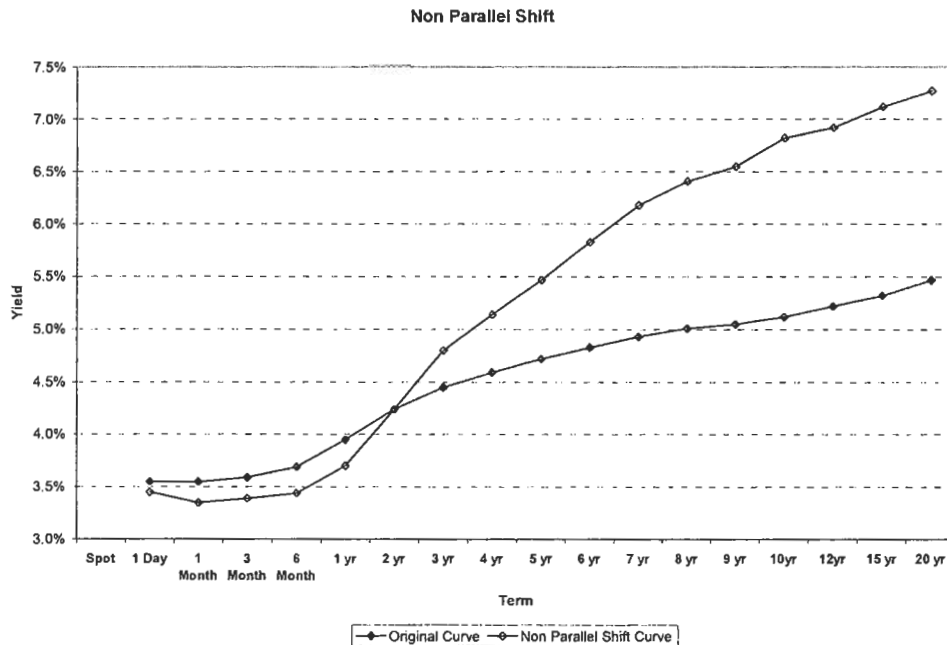
### Steeper Yield Curve

The chart below shows a non-parallel shift:



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The 6-month horizon analysis is shown below:

	% Return				
	Bullet	Barbell			
Original Curve	5.15%	4.90%	10,257,526	10,244,996	(12,529)
Non Parallel Shift	-0.05%	-4.06%	9,997,368	9,797,187	(200,181)

Both strategies lose money. The barbell losses are greater than losses for the bullet.

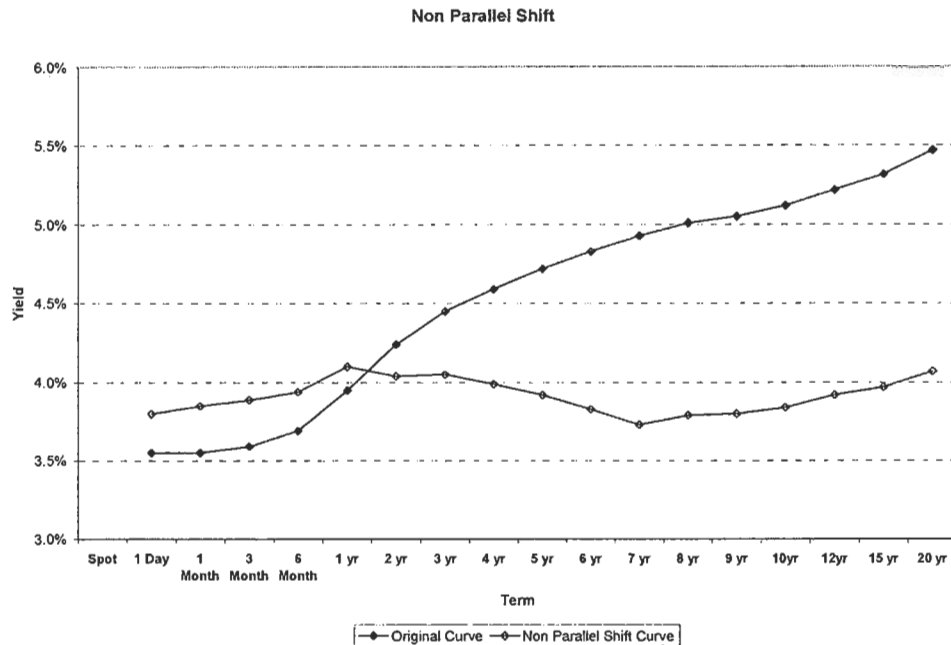
### Lower Flatter Yield Curve

The chart below shows a non-parallel shift:



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The 6-month horizon analysis is shown below:

	% Return		Bullet	Barbell	Difference
	Bullet	Barbell			
Original Curve	5.15%	4.90%	10,257,526	10,244,996	(12,529)
Non Parallel Shift	10.94%	13.56%	10,547,170	10,678,199	131,030

The barbell outperforms the bullet as the yield curve flattens

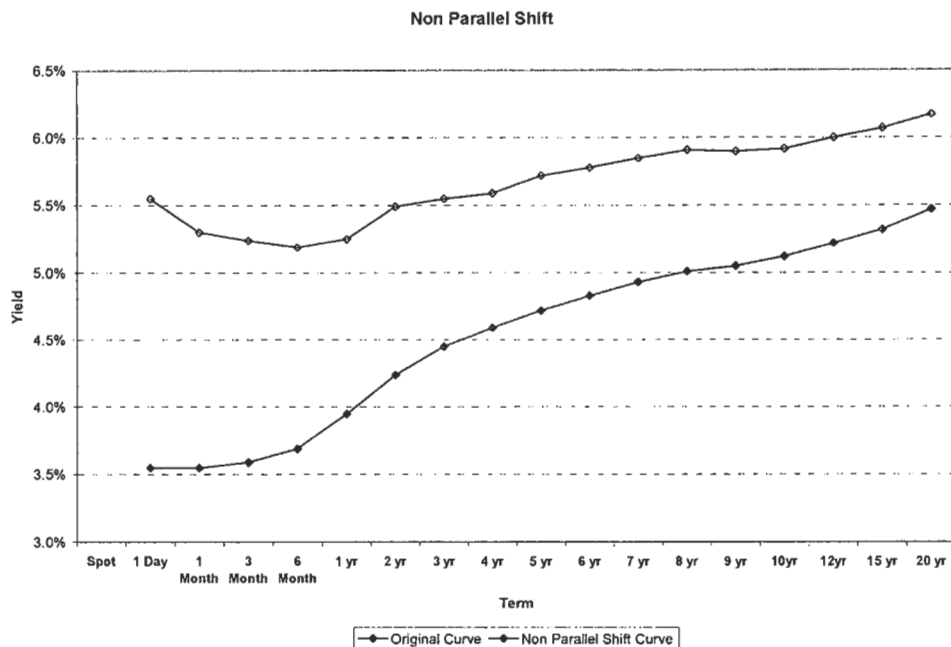


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### Higher Flatter Yield Curve

The chart below shows a non-parallel shift



The 6-month horizon analysis is shown below:

	% Return		Bullet	Barbell	Difference
	Bullet	Barbell			
Original Curve	5.15%	4.90%	10,257,526	10,244,996	(12,529)
Non Parallel Shift	-2.47%	-2.18%	9,876,338	9,891,073	14,735

The barbell position outperforms the bullet by a slight margin.



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### **Basis Trading**

Basis trading involves arbitrage between bonds and bond futures. Bond futures have a delivery option – for the bond futures seller a number of different options can be delivered.

The delivery option involves uncertainty involving which bond will actually be delivered into the futures contract. Supply and demands imbalances in the cash bonds that will be delivered can create arbitrage opportunities.

Using basis offers portfolio managers a tool for enhancing yields.

Instead of a view on interest rates in general, the portfolio manager must have a view on the relationship between futures prices versus cash bond prices.

There are three alternatives for the relationship between futures and cash:

- Basis spread widens
- Basis spread narrows
- Basis spread remains constant

Trades can be constructed anticipating basis spread changes using cheapest to deliver bonds as well as bonds that are not cheapest to deliver.

### **Buying the Basis**

When the view is that the implied repo rate will decrease over a defined horizon period, a strategy that will make money is known as *buying the basis*.

This trade involves:

1. Buying the cash bond
2. Selling the future

The buyer of the basis will profit if the gross basis remains high; i.e. the difference between the clean bond price and the equivalent futures price remains large.

**If the gross basis remains large, the implied repo rate declines. The buyer of the basis has a view that the basis will not decline and the implied repo rate will fall.**

When the trade for the buyer of the basis is reversed out at the horizon date, P&L arises from the following parts:

1. Difference between the gross basis on trade date and horizon date—this is usually a **negative** impact for the buyer.

The gross basis will tend to shrink because the price of the cash bond converges to the futures price. For the CTD bond, on delivery date the gross basis is 0: the cash price is equal to the futures price adjusted by the conversion factor.

2. Accrued interest—**positive** for the buyer

The buyer of the basis earns the accrued interest because he owns the cash bond.

3. Financing rate for the horizon period—**cost/negative** for the buyer



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Financing cost is based on the repo for that period.

The difference between 2 and 3 above is known as the **projected carry**.

**If the decline in gross basis is less than the amount of projected carry, this strategy will make money.**

This can be seen directly by looking at the **net basis** instead of the gross basis. For a long basis trade:

1. A decrease in the net basis means the trade loses exactly that much.
2. An increase in the net basis means the trade makes exactly that much.

The breakeven gross basis amount exactly offsets the projected carry:

$$\text{Projected Carry} = (\text{Horizon Date AI} - \text{Settlement Date AI}) - \text{Financing Costs}$$

$$\text{Current Gross Basis} = \text{Clean Bond Price} - (\text{Futures Price} \times \text{Conversion Factor})$$

$$\text{Breakeven Gross Basis} = \text{Current Gross Basis} - \text{Projected Carry}$$

### Buying the Basis: Non-Cheapest to Deliver Bond

The first example illustrates a long basis trade using the Sep 98 Pfandbrief future contract.

The trade is executed on 11-May-98 using the 4.75% Hypo Essen Öpfe with maturity 16-April-2002. The trade is unwound on 11-June-98.

Principal	10,000,000	Maturity	16-Apr-02
Last Coupon	16-Apr-98	Coupon	4.75%
Next Coupon	16-Apr-99	CF	0.960406
Futures Delivery	10-Sep-98	Accrued	0.369
		Contracts	(38)

The number of contracts to sell is based on the conversion factor and the underlying principal of a single contract (DEM 250,000):

$$\# \text{ Contracts} = \frac{\text{Cash Bond Principal}}{250,000} \times \text{Conversion Factor}$$

Market changes over the holding period:

	<u>Beginning</u>	<u>Unwind</u>	<u>Difference</u>
Spot	11-May-98	11-Jun-98	
Settlement	14-May-98	16-Jun-98	33
Futures	104.16	104.00	(0.16)
Clean Price	100.520	100.320	(0.200)
Accrued	0.369	0.792	0.422
Dirty Price	100.8895	101.112	0.222
Yield	4.600%	4.653%	
Repo rate	3.21%	3.21%	



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Using a horizon date of 16-June-98 the results of the analysis are shown below:

	<u>14-May-98</u>	<u>16-Jun-98</u>	<u>Change</u>
Gross Basis	0.484%	0.438%	(0.046%)
Coupon Earned	1.531%	1.108%	0.422%
Repo Costs	1.071%	0.775%	(0.295%)
Net Basis	0.024%	0.105%	0.081%
Implied Repo	3.138%	2.776%	(0.362%)
Bond Price	10,052,010	10,032,000	(20,010)
Accrued	36,944	79,167	42,222
Total Bond	10,088,954	10,111,167	22,212
Future			15,366
Repo Costs			(29,516)
Price Moves			(4,643)
Carry			<u>12,706</u>
Net P&L			8,063
Net Return			0.880%

Under this scenario the buyer of the basis makes money.

The cash price decreased faster than the futures price and gross basis decreased from 0.484% to 0.438%. The positive carry more than compensates the negative effects from the shrinking basis.

The Pfandbrief loses DEM 20,010 (clean price), the future generates a profit of DEM 15,366. The net of DEM 4,643 corresponds to the observed **basis change** of negative 0.04643%.

Carry comes to positive DEM 12,706, being the net between accrued interest of DEM 42,222 and repo cost of DEM 29,516.

The total P/L comes to DEM 8,063. This is the same result we get from the **change of net basis**.

### Breakeven Analysis

The breakeven gross basis for this transaction is shown below:

$$\text{Projected Carry} = (\text{Horizon Date AI} - \text{Settlement Date AI}) - \text{Financing Costs}$$

$$\text{Current Gross Basis} = \text{Clean Bond Price} - (\text{Futures Price} \times \text{Conversion Factor})$$

$$\text{Breakeven Gross Basis} = \text{Current Gross Basis} - \text{Projected Carry}$$

<u>Breakeven Analysis</u>	
Gross Basis	0.484
Accrued	0.422
Repo Cost	<u>0.297</u>
Projected Carry	0.125
Breakeven Basis	0.359
Forward Implied Repo	3.103%



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As long as the gross basis stays above 0.359 on 16-Jun-98 the buyer of the basis makes a profit. The actual gross basis is greater than the breakeven basis and the long basis trade earns money.

The breakeven forward rate is calculated using the breakeven basis above.

$$\text{Implied Repo Rate} = \frac{\text{Accrual} - \text{Breakeven Basis}}{\text{Dirty Price}} \times \frac{360}{\text{\#days}}$$

The farther the implied repo rate moves below 3.103% the more the buyer of the basis earns. On 16-June-98 the implied repo stood at 2.776%, so this is a winning trade.

Long basis P&L as a function of the implied repo rate is shown below. The table shows the P&L from this transaction for different levels of gross basis and implied repo on 16-June-98:

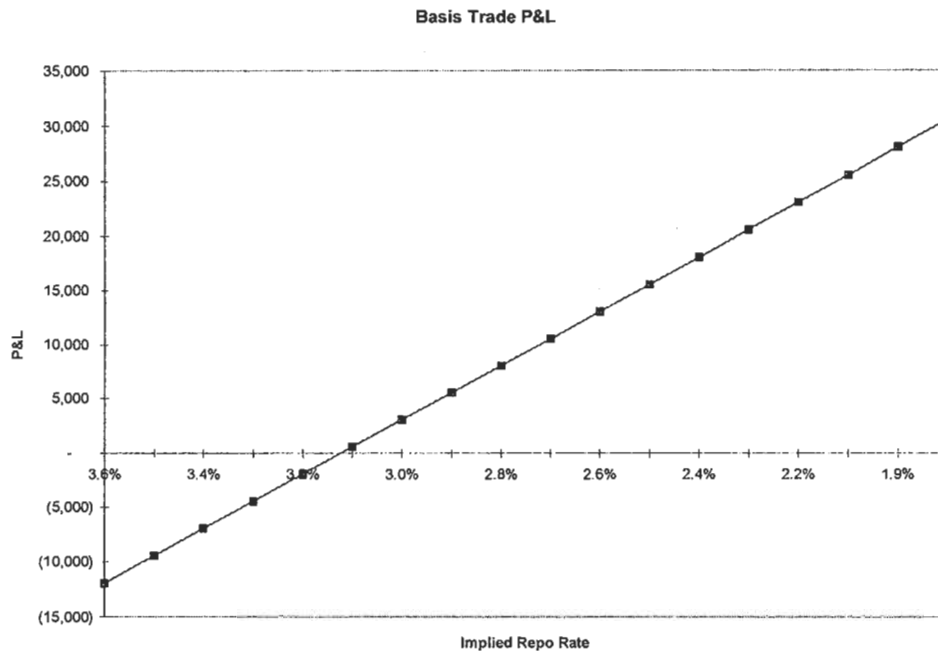
<u>Gross Basis</u>	<u>Implied Repo</u>	<u>P&amp;L</u>
0.238	3.604%	(11,937)
0.263	3.501%	(9,437)
0.288	3.397%	(6,937)
0.313	3.294%	(4,437)
0.338	3.190%	(1,937)
0.363	3.087%	563
0.388	2.983%	3,063
0.413	2.880%	5,563
0.438	2.776%	8,063
0.463	2.673%	10,563
0.488	2.569%	13,063
0.513	2.466%	15,563
0.538	2.362%	18,063
0.563	2.259%	20,563
0.588	2.155%	23,063
0.613	2.052%	25,563
0.638	1.948%	28,063
0.663	1.845%	30,563

The table is shown in the following chart.



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### ***Selling the Basis: CTD Bond***

If our view is that the gross basis will decline then a short basis trade will show a profit.

This trade involves:

1. Selling the cash bond
2. Buying the future

Our view is that the price of the cash bond and the future will converge; gross basis will decline. This will take place if the bond we sell stays or becomes CTD.

#### Example of Selling the Basis

Setting this strategy up with a Non-CTD-Bond is pretty risky. Even if the CTD changes that does not mean that "our" bond becomes CTD.



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For a short basis trade we show the 6% March 02 (CTD) bond from 14-May-98 to 16-Jun-98. The analysis is dependent on the CTD bond remaining CTD.

	<u>14-May-98</u>	<u>16-Jun-98</u>	<u>Change</u>
Gross Basis	0.825 %	0.585 %	0.240 %
Coupon Earned	1.933 %	1.400 %	-0.533 %
Repo Costs	1.123 %	0.812 %	0.310 %
Net Basis	0.015 %	-0.002 %	0.017 %
Implied Repo	3.168%	3.219%	0.050%
Bond Price	(10,493,965)	(10,454,000)	39,965
Accrued	(86,667)	(140,000)	(53,333)
Total Bond	(10,580,632)	(10,594,000)	(13,368)
Future			(15,993)
Repo Costs			31,031
Price Moves			23,972
Carry			(22,302)
Net P&L			<u>1,670</u>
Net Return			0.182%

The basis itself converged, thus generating a profit for the seller of the basis.

The carry is negative as the repo rate is lower than the accrued interest. The negative carry is compensated by a slight margin by the positive effect of converging basis.

Net profit is DEM 1,670 as can be seen as well from the change in net basis.

### Risks in Short Basis Trade

The short basis trade involves receiving the repo rate. In this case we assumed a term repo of 3.21%. It might be difficult to enter a term repo. The trader may have to roll over the repo transaction.

If the repo rate declines, the negative carry on the short basis trade increases and the profitability declines.

Most short basis trades are executed early on when the future in a particular month begins trading.

If the cash bond used in the trade is the CTD bond the basis will decline over time and the short basis trade will generate a profit.

There are two risks to this type of short basis trade:

- The original CTD bond switches. The gross basis will not decline.
- The repo rate for the bond falls and the short basis trader has to re-borrow the bond.

### **Trading the Implied Repo Rate**

We can also use the inverse relationship between gross basis and implied repo rate for CTD bonds in establishing basis trades.



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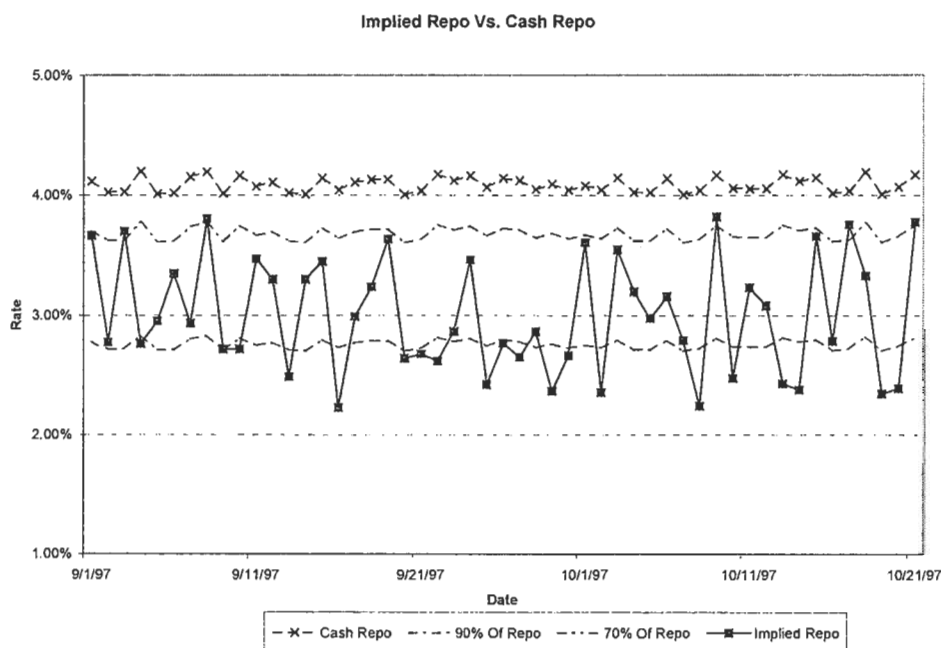
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For CTD bonds the gross basis will decline and the implied repo rate will remain fairly constant.

Traders look for abnormally high or low implied repo rates versus the same term market repo rate.

Because the implied repo rate trades at a level below the normal repo rate, one could look at the implied repo rate as a percentage of the cash repo rate.

The following graph shows the cash overnight repo rates and a range of 90% and 70% of this rate. This has been a typical range in the German market. The implied repo rate should trade between these bounds. The implied repo rate is for the cheapest to deliver bond.



There are certain points where the implied *repo trades above the range*. This may indicate a good opportunity to make a profit by:

1. Buy the cash bond and finance the purchase using repo
2. Sell the futures contract

This is a long basis trade. If the implied repo rate declines to its expected level, the gross basis will increase. The long basis trade will show a profit.

There are also times where the implied *repo trades below the range*. This could represent an opportunity to make money by executing the following transaction.

1. Sell the cash bond and earn the repo rate
2. Buy the futures contract



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This is a short basis trade. If the implied repo rate increases, the gross basis declines and the short basis trade shows a profit.

The number of futures contract to buy or sell is adjusted by the conversion factor of the cash bond.

### **Asset Swaps**

Asset swaps are the purchase of a bond and the simultaneous swap of the bond cash flow. This transaction can create a floating rate instrument with a positive spread to financing costs.

Portfolio managers use asset swaps to act on a particular view concerning yield movements.

On 28-Apr-98, pricing for an issue is below. The settlement date has been altered slightly to structure the transaction with 0 accrued interest.

Settlement Date	28-April-1998
Issuer	Export Development Corp
Principal	\$100,000,000
Maturity	28-April-2003
Coupon	6.000%
Clean Price	99.650%
Yield	6.083%
Accrued Interest	0.000%
Dirty Price	99.65%
Equivalent Swap Yield	6.140%
Yield Spread Vs. Swap	-0.057%



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### Interbank Libor Curve

In order to price asset swaps we need to have the current Libor curve. As of 24-April-1998 (spot date 28-Apr-1998), Libor deposits, swap rates and PV factors are shown below. Also shown are PV factors calculated for the same rates but at the horizon date of 26-May-1998.

		USD	
LIBOR Rate Inputs	Updated as of	24-Apr-98	26-May-98
	Rate	PV Factor	PV Factor
O/N	5.66%	0.99984	0.99984
1M LIBOR	5.66%	0.99531	0.99500
3M LIBOR	5.69%	0.98583	0.98567
6M LIBOR	5.75%	0.97160	0.97115
12M LIBOR	5.88%	0.94378	0.94378
LIBOR Quote Convention		Act/360	
Par Coupon Swap Rate Inputs			
2 Yr	6.08%	0.88859	0.88845
3 Yr	6.10%	0.83689	0.83716
4 Yr	6.13%	0.78792	0.78805
5 Yr	6.14%	0.74214	0.74214
6 Yr	6.16%	0.69828	0.69828
7 Yr	6.20%	0.65567	0.65546
8 Yr	6.21%	0.61681	0.61671
9 Yr	6.23%	0.57929	0.57948
10 Yr	6.25%	0.54412	0.54412
Swap Quote Convention		30/360, A	

These PV factors will be used throughout this section.

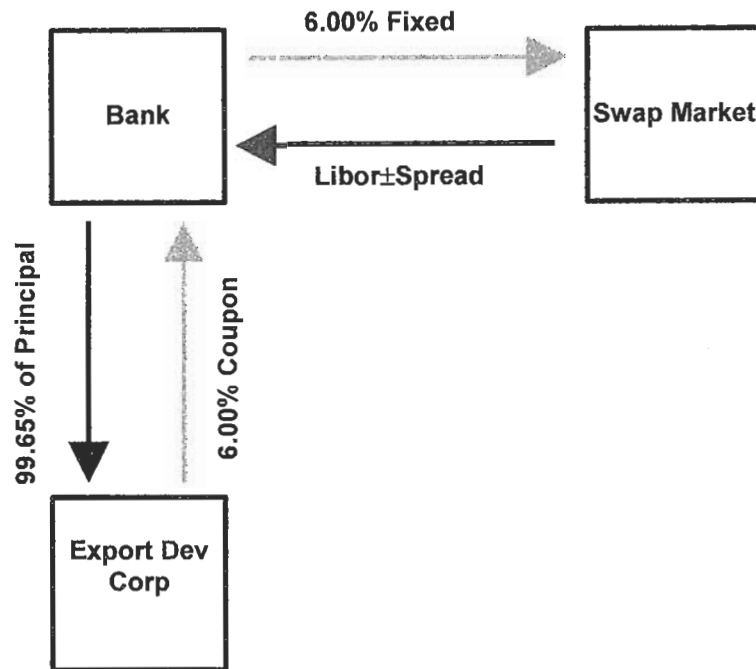
If the view is that the bond-swap spread will decline or become more negative, the correct strategy is to buy the bond and enter into a swap to pay the fixed rate and receive the floating rate.



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### Bond/Swap Arbitrage



The spread value is defined as:

$$(\text{Underlying Asset Price} - 100\%) - \text{SwapValue} = -\text{Spread} \times \sum_i \text{PVf}_i \times \text{Accrual Factor}_i$$

$$\text{Spread} = - \frac{(\text{Underlying Asset Price} - 100\%) - \text{SwapValue}}{\sum_i \text{PVf}_i \times \text{Accrual Factor}_i}$$

For any bond we can create the asset swap structure and determine the spread. Be careful that the basis and accruals are correct.

Notice that the value of the spread is determined by the relationship between how far the bond is priced from par and the swap value. Swap value indicates how far a swap is price from par.

The more under-priced the bond is relative to the swap market the higher the spread to Libor.



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The bank will make an up-front payment on the swap because the fixed-rate coupon of 6.00% is less than the market swap rate:

	Swap
PV Fixed	25.196%
Accrued Interest	0.000%
PV Fixed With Accrued	25.196%
PV Floating	25.786%
Net Price	0.590%
Market Yield/Rate	6.14%
Yield Convention	30/360 p.a.

Details on the above calculations follow:

Date	Accrual	PVf	Cash flow	PV Fixed	PV Floating
28-Apr-98		1.00000		25.196%	25.786%
28-Apr-99	1.000	0.94378	6,000,000	5,662,696	
28-Apr-00	1.000	0.88859	6,000,000	5,331,550	
30-Apr-01	1.000	0.83689	6,000,000	5,021,347	
29-Apr-02	1.000	0.78792	6,000,000	4,727,541	
28-Apr-03	1.000	0.74214	6,000,000	4,452,821	

Because the swap has positive mark-to-market value for the bank, the bank makes an up-front payment of 0.590% to enter into the swap. This is because the coupon of 6.00% is below the current market swap rate of 6.14%.

The bank pays 0.590% and purchases the issue at a discount of 0.350%. The net difference is the bank pays out 0.24%. This is equivalent to spread of 0.056% act/360 semi-annual basis.

	Bond	Asset Swap
PV Bond Coupon	25.1960%	-25.1960%
PV Libor		25.7863%
Difference		
Bond "under par"	+0.3500%	
Accrual	0.0000%	
"under par" + Accrual	+0.3500%	-0.5904%
PV Difference		-0.240%
Libor Spread		-0.056%

If the bond was yielding 6.14% (swap yield), the price would be 99.41%. The discount would be 0.590% which would exactly offset the payout of the swap. The net Libor spread would be 0.

The Libor spread of 0.056% represents the difference between the swap market and bond market taking into account the correct basis and accrual conventions.



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We will demonstrate that if the view is the Libor spread becomes more negative, the opportunity exists to realize a profit.

### Horizon Return

The portfolio manager must measure the return on the transaction over a period of time. We will assume the horizon period is one month (26-May-1998) and actual Libor deposits and swap rates have remained constant over the horizon period.

The swap rate to 28-April-2003 has declined slightly because the actual swap is now one month shorter and generic swap rates have not changed.

	<b>Swap</b>
PV Fixed (Incl. Accrued)	24.869%
PV Floating	25.418% <sup>1</sup>
Net Price	0.549%
Market Yield	6.137%

Assume the bond yield on the issue has declined to 6.07% for a price of 99.70%.

	24-Apr-98		26-May-98	
	<u>Swap</u>	<u>Bond</u>	<u>Swap</u>	<u>Bond</u>
PV Fixed	25.196%		24.869%	
PV Floating	25.786%		25.418%	
Net Swap Value	.590%	99.65%	0.549%	99.70%
Market Yield	6.140%	0.00%	6.137%	6.070%
Spread		-0.057%		-0.067%

The bond-swap yield spread has widened from -5.7 basis points to -6.7 basis points. The table below demonstrates the P&L and the return on this transaction.

	24-Apr-98		26-May-98		
	<u>Price</u>	<u>Amount</u>	<u>Price</u>	<u>Amount</u>	<u>Net</u>
Bond					
Price	99.65%	(99,650,000)	99.70%	99,697,066	47,066
Accrued	0.00%	-	0.50%	500,000	500,000
Total	99.65%	(99,650,000)	100.20%	100,197,066	547,066
Swap					
Up-front	0.590%	(590,357)	0.549%	548,875	(41,482)
P&L					505,584
Return					6.067%

The annualized return over a 1-month period is 6.067%. This is composed of the gain on the bond due to a decline in rates, accrual of the bond coupon, and loss on the swap.

In order to execute the strategy cash must be borrowed to buy the bond. The return above must be compared to the cost of borrowing funds over a 1-month period.

<sup>1</sup> Contains first period rate reset of 5.75%



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**This strategy must earn more than the cost of financing the bond over a particular horizon period. The cost will depend on the borrowing rate for the trader.**

The accrued interest on the bond yield produces a return of 6.00%. The widening of the spread between the bond yield and swap yield increased the return by 0.067%.

### ***Conclusion***

An asset swap structure can be used to act on a view about yield differentials between bond issues and swaps. Strategies can be constructed if one believes the yield spread will narrow or widen. **These strategies do not depend on rate moves in one particular market but on the relationship of rate moves in two markets.**

### **Arbitrage Strategy Quantitative Factors**

The following sources of return can be present in some or all of the arbitrage strategies previously discussed.

### ***Competitive Financing***

Arbitrage usually involves very narrow profit margins. Strategies only make sense if they are leveraged. Being able to finance a large balance sheet at attractive rates (sub-Libor) is necessary.

### ***Repo Financing***

Very often financing specific bond is accomplished using the Repo rate. The ability to get good Repo quotes is one factor behind arbitrage transactions.

### ***Technology / Modeling***

Arbitrage strategies can involve complex modeling and analysis. Significant capital needs to be invested in modeling capabilities and systems to implement these models.

### ***Liquidity***

Many arbitrage strategies involve buying or selling a liquidity premium. This premium is the difference between securities with similar characteristics except for supply and demand.

### ***Time and Effort***

Arbitrage strategies can involve a great deal of effort to take a large group of potential securities and narrow the universe down to a few securities that are actually traded. Much time must be allocated to analyzing a large number of securities and checking bid/offer quotes.

Timing and execution are a factor in the profitability of arbitrage strategies.



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### ***Event Risk***

Arbitrage gains/losses result from extraordinary events occurring or the perception of future extraordinary outcomes.

Historically, Brady Bonds in 1995 was a market that experienced a great deal of supply. This was followed by large returns.

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